CARIBOU AND MUSKOXEN

IN THE LANCASTER SOUND-BARROW STRAIT REGION, NWT

by

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Western and Northern Region

1. NATURAL HISTORY OF CARIBOU IN THE REGION

1.1 Taxonomy

Two subspecies of caribou occur in the region: barren-ground caribou (Rangifer tarandus groenlandicus) on Baffin Island and Peary caribou (R. t. pearyi) on Devon, Cornwallis, Little Cornwallis, Bathurst, Prince of Wales, Somerset and on smaller islands in Barrow Strait and Peel Sound. Caribou from Boothia Peninsula migrate to Prince of Wales and Somerset islands in the spring (Miller and Gunn 1978a) and they probably return in early winter. Some of those caribou may be Peary caribou, that winter on Boothia Peninsula along with barren-ground caribou, or integrades. Interchange of caribou between Prince of Wales Island and Victoria Island is possible but the taxonomic status of caribou on Victoria Island is not known.

Peary caribou are thought to have radiated out from a refugium in the western Queen Elizabeth Islands (Banfield 1961) or from one on northern Greenland (Macpherson 1961). The Peary caribou south of Parry Channel may have interbred with barren-ground caribou that formerly migrated from the mainland in spring to adjacent islands including Victoria, King William, and perhaps Prince of Wales and Somerset. A second possibility is that slightly larger forms of the Peary genotype have evolved in response to the more southerly environment.

The large land mass of Baffin Island gives it more of a continental type climate and environment which permits the caribou to range over more varied habitats. Those differences result in more diversification of vegetation and greater average depths of snow cover and thus most likely explains why barren-ground caribou are found there.

1.2 Physical Description

The winter pelage of barren-ground caribou is predominantly brown with a white mane and lateral line, whereas Peary caribou are largely white with darker patches on the face, upper back and legs. The winter pelage of Peary caribou is considerably longer than that of barren-ground caribou, an adaptation to the more rigorous climate on the northern Arctic Islands.

Barren-ground caribou are larger and heavier than Peary caribou. Although differences in total body weight and body size appear real among groenlandicus and pearyi, seasonal differences within each subspecies in body weight, especially for mature bulls, are so great that they tend to mask the differences between males and females and subspecies. Generally, however, mature cows of each subspecies are about 10-15% smaller and much lighter than mature bulls of each subspecies. The weights for most Peary caribou were obtained in late winter when fat reserves were low or depleted. Males averaged 78 kg and females 55kg. Autumn weights are considerably higher. Five adult males obtained on Prince of Wales Island in August 1978 averaged 203 kg (range 177-211 kg) but their taxonomic position is uncertain.

The appendages (legs, ears and noses) of Peary caribou are shorter than those of barren-ground caribou but their hooves are larger in absolute terms and larger relative to their size and weight.

1.3 Distributions and Movements

Caribou are highly mobile and tend to be distributed widely for much of the year. There are definite movement patterns although spatial and temperal changes also occur in response to environmental variations: climatic or population size. We now know that some Peary caribou migrate between summer and winter ranges which may be on different islands (Miller et al. 1977a, 1977b; Miller and Gunn 1978a, 1979a; Miller and Kiliaan 1980).

1.4 Composition

Several types of groups occur: 1) cow-calf pairs; 2) family or clan groups of mature females, juveniles, yearlings and calves, sometimes with some adult bulls present; 3) sex or age-class groups of adult bulls or juveniles or yearlings of the same or different sexes. The annual cycle of group formations of Peary caribou is similar to that for barren-ground caribou, but on a smaller scale. The smaller seasonal groupings of Peary caribou most likely reflect both their relatively low numbers and the general sparse vegetation on their ranges. For both subspecies the groups are smallest in the winter period, often 3-5 individuals for Peary caribou and 5-10 or more for barren-ground caribou. Barren-ground caribou form large post-calving aggregations of several hundreds or thousands while post-calving aggregations of Peary caribou seldom exceed 100-200 and usually are fewer than 50 in number.

1.5 Reproduction

Caribou in the wild under favorable conditions are capable of producing one calf each year beginning at 2 years of age. Unfavorable conditions can delay puberty or suspend productivity in adults. In most populations, caribou do not produce their first calf until they are 3 years old. Breeding begins in October and a high proportion of conceptions occur within a span of 2 weeks (Dauphine 1976). Most of the calves are born in June after a gestation period of abount 7.5 months.

1.6 Mortality

Major causes of mortality are by man and other predators. Of sporadic importance are severe storms at calving, diseases, parasites, insect harassment, abandonment of calves, accidents and injuries. Mortality of caribou calves to 1-year of age usually is 40-75%. It can be total or nearly so in some years when extremely harsh weather occurs at calving, or in extremely severe winters, especially in combination with unfavorable foraging conditions in summer.

Numbers of Peary caribou appear to be more influenced periodically by unfavorable snow or ice conditions than are numbers of barren-ground caribou. Both subspecies may move several hundred kilometres to find favorable feeding conditions.

1.7 Habitats and Diets

Peary caribou exploit a wide range of habitat types, however, they tend to avoid wet habitats in summer. In summer the caribou utilize growing forage and select the most nutritious parts such as flower and seed heads and leaves (Shank et al. 1978). Summer diets are predominantly leaves of willow (and dwarf birch to the south), flowers

and seeds of forbs and grasses and sedges. In winter Peary caribou exploit habitats where the snow is shallow or soft. Snow is shallow on the tops of ridges or where vegetation is sparse and consequently does not trap snow. In some winters vast areas of poorly-vegetated terrain are blown almost clear of snow for most of the winter. Soft snow may occur in the lee of boulders, rocks and ridges and among hard drifts. Conditions most detrimental to winter foraging are ice or hard drifts at the surface of the ground. Icing may be caused by rains, mostly at freeze up, and by melts during the winter and annually during the springtime melt. Forage utilized by Peary caribou in winter includes grasses and sedges, willow stems, lichens, Saxifraga oppositifolia, and mosses. The latter group may occupy 40-75% of the rumen contents in winters when forage is difficult to obtain.

The seasonal diets of barren-ground caribou on Baffin Island are unknown but possibly follow more closely those of Peary caribou than those of barren-ground caribou on the mainland. This condition probably reflects types of forages available to them and learned behavior more than racial genetic differences.

The barren-ground caribou on Baffin Island tend to winter on the rugged broken terrain of southeasten and southern regions and to summer on the low rolling land on the western side and in the central lake-basin region. Little is known about northern Baffin Island, but fragmentary reports in Macpherson (1963) indicate that caribou do occur throughout the area, especially in autumn and winter.

2. NATURAL HISTORY OF MUSKOXEN IN THE REGION

2.1 Taxonomy

Tener (1965) concluded that there was insufficient evidence to identify subspecies and therefore muskoxen were monotypic, i.e., Ovibos moschatus. Formerly the island populations were described as O. m. wardii and the mainland form as O. m. moschatus. All supposed forms of muskoxen showed considerable geographic variability and differences in skull size were attributed to nutritional differences. Most muskoxen examined from the Canadian Arctic Islands have styles on one or more of the upper molars, a diagnostic character. Those styles are absent from most muskoxen examined from mainland regions. Manning and Macpherson (1961) found muskoxen with and without styles in samples from Prince of Wales Island. Thus, they suggested that muskoxen had arrived from the Queen Elizabeth Islands in recent years.

2.2 Physical Description

Muskoxen are dark, stocky, short legged, long-haired animals with relatively large heads bearing horns in both sexes. Coarse hair hangs down from the body to form a skirt which protects calves from the wind. A fine wool (quivet), natures finest fibre, provides the insulation needed in such a cold climate. Four bulls from the mainland averaged 340 kg but captive muskoxen attained 658 kg (Tener 1965). Cows are only about two thirds the weight of males (Hubert 1974), but few measurements have been taken. Height to the top of the shoulder region is seldom over 1.5 m.

2.3 Distribution and Movements

Muskoxen occur on all the large Arctic Islands in Canada with the exception of Baffin Island. They also occur on the mainland tundra but only in certain regions. Historically muskoxen occupied most of the tundra regions in Canada but whalers, trappers and native hunters with rifles extirpated muskoxen from many regions. Peary shot at least 600 muskoxen between 1898 and 1909 and several thousand undoubtedly were killed by whalers and early explorers in the Canadian Arctic Islands (Hone 1934).

Muskoxen in summer move among feeding sites within a general region but in winter they tend to remain in one location for days or weeks. Considerable variation among regions and herds in the degree of movements precludes hardfast generalizations.

2.4 Composition of Herds

Hubert (1974) found that the composition of 243 muskoxen on the Devon Island lowlands was 30.0% adult males, 35.4% adult females, 3.3% 3-year-olds, 2.5% 2-year-olds, 14.0% yearlings and 14.8% calves. The sex ratio of adults is about equal (Tener 1965; Gray 1973), but favors cows in several populations (Tener 1965), and was weighted towards bulls in another (Spencer and Lensink 1970).

The proportion of solitary muskoxen is much higher in summer than in winter. The mean herd size on Bathurst Island in summer 1961 was only 5.6 but it was 11.7 on Melville Island. In hilly or mountainous areas the average herd size is much larger than it is on flatter terrain. On the Bailey Point region in April 1980, the mean herd size was 29.4

compared with 12.5 in herds on the southeastern coast and 11.5 in herds on Dundas Peninsula (Thomas unpubl.). Miller et al. (1977a) suggested that the larger groups in winter were responses to forage inaccessibility and to predators. Gray (1973) suggested that group size was also a function of muskoxen densities in a particular region and also, presumably, among regions.

2.5 Reproduction

The age of puberty is dependent on rate of growth and accumulation of fat reserves. Both sexes are capable of breeding as yearlings and annually thereafter under captive conditions. In their natural state puberty is not attained until the females are 2 1/2 or more commonly 3 1/2 years old (Tener 1965; Hubert 1974). Tener (1965) and Hubert (1974) believed that muskoxen usually had calves every second year once they became fertile. Hubert (1974) observed calves 10-13 months of age still nursing presumably on their mothers.

Breeding begins in late July and may extend into early October (Hubert 1974). With a gestation period of 8 months (240-250 days), calving occurs from mid-April to early-June (Tener 1965). Twins occur only rarely. In captivity stillborn male and female muskoxen weighed 11 and 12 kg, respectively (Wilkinson 1973).

2.6 Mortality

The greatest mortality is among calves and yearlings, predominantly from predation or malnutrition. The exception is extreme winter weather when subadults and the old (especially males) secumb (Parker et al. 1975) because they have lower reserves of fat. Muskoxen on Prince

Patrick Island died out between 1953 (MacDonald 1954) and 1961 (Tener 1963). Mortality was high on Devon Island during the winter of 1966-67 (Hubert 1974).

2.7 Habitats and Diets

In summer on the Canadian Arctic Islands, most muskoxen are found in lowland, wet habitats where extensive sedge meadows are common. In June, July and August most muskoxen are located in coastal regions and in major river valley which extend inland. Occasionally they are found in upland meadows and in meadows formed by seepage from late-melting snowbanks. In winter the lowland meadows are utilized unless the snow is too deep or hard, in which case the vegetation on adjacent drier sites is utilized.

Diets are predominantly grasses and sedges and Carex stans is the most important forage species in the Canadian Arctic Islands. Willows are probably the second most important group in the diets of muskoxen and they may predominate in the diets of some groups of muskoxen in the summer.

3. PRESENT KNOWLEDGE

3.1 Numbers of Caribou

Our data on current numbers of caribou on all the areas around Lancaster Sound-Barrow Strait are poor. The last published estimate of the Baffin Island population was 20,000 in 1974 (Calef 1978). The average harvest over 3 years from 1972-73 to 1974-75 was 2,485, which was larger than the estimated recruitment and suggested a decreasing

population (Calef 1978). Others (e.g. Chowns, pers. comm.) believe that the population is much higher. There never has been a survey of the entire island.

Macpherson (1963) believed that the caribou on Baffin Island were increasing in number, although data from the existing aerial surveys were fragmentary and subject to various errors. He guessed, based on the manipulation of survey estimates, that there were 25,000-30,000 caribou on Baffin Island (494 690 km^2).

The estimated population of Peary caribou on Devon Island in June 1961 was 150, based on an aerial survey with 6.1% coverage of the 37 550 km^2 of potential habitat (Tener 1963). Except for one caribou observed near Radstock Bay, all the observed caribou were on northeast Devon Island, the majority on Grinnell Peninsula. Hubert (1974) observed no caribou on the northern lowlands and suggested that they emigrated or were extirpated. Caribou remains were common in pre-Dorset, Dorset and Thule Eskimo campsites at Cape Sparbo (Lowther 1960). Bissett (1968) concluded that few caribou inhabited Devon Island.

Aerial surveys of 7.1% of Cornwallis Island and 10.7% of Little Cornwallis Island in June 1961 produced estimates of 43 and 0 Peary caribou, respectively (Tener 1963). Surveys in May and July of 1974 and April and June 1975 provided estimates of 4, 52, 31 and 0 Peary caribou, respectively (Fischer and Duncan 1976). All the observed caribou were in the northwest section of the island.

The caribou population on Bathurst and its satellite islands in late June-early July 1961 was estimated at 3,565 (8% coverage).

Estimates were: south Bathurst 13, northeast Bathurst 1,486, northwest Bathurst 1,274, and satellite islands (Alexander, Massey, Vanier, Cameron and Helena) 842. Population totals for all those regions (Greater Bathurst Island) in 1973 and 1974 were 797 and 256, respectively (Miller et al. 1977a). The decline from 3,565 in 1961 to 797 in 1973 was attributed to climatic factors and to hunting mortality. Bathurst Island was the primary hunting area for the Inuit of Resolute Bay until 1974 when hunting was suspended there.

The decline from 1973 to 1974 was attributed primarily to the severe winter of 1973-74 (Miller and Russell 1975, Miller et al. 1977a, Parker et al. 1975). Aerial surveys conducted on Bathurst and its satellite islands by Renewable Resources Consulting Services Limited in August 1974, in April 1975, and in June 1975, produced estimates of 228, 120, and 361 caribou, respectively (Fischer and Duncan 1976).

Aerial surveys of Prince of Wales Island in June and late July of 1974 and in April and June 1975 yielded estimates of 1,040, 5,437, 581 and 3,768 caribou (Fischer and Duncan 1976).

Population estimates for Somerset Island were 245 in June 1974, 645 in March 1975, and 903 in June 1975 (Fischer and Duncan 1976). Combining the maximum totals for each island, each year, the 1974 and 1975 estimates were 5,682 and 4,671. The totals are combined because caribou migrate between those islands (Miller and Gunn 1978a) as well as to and from Boothia Peninsula (Miller and Gunn 1979a, Miller and Kiliaan 1980).

3.2 Distribution and Movements

Distributions and movements of the barren-ground caribou on Baffin Island are virtually unknown. Macpherson (1963), recorded many observations in the southcentral region but few in the northern half of the island. Current information is not available but we can assume that caribou still favour the high broken ground of Baffin Island in winter and the low, rolling country in summer.

The few caribou seen on western Devon Island in 1961 were located on Grinnell Peninsula. They most likely are part of the Bathurst and Cornwallis islands group of caribou although interchange with the caribou of Bjorn Peninsula (Ellesmere Island) is a possibility. Interchange between Bathurst Island and Cornwallis Island was never documented by direct observation but there was strong evidence that in late winter of 1974 caribou moved from southeast Bathurst Island to Cornwallis Island and to islands in Barrow Strait. Although those caribou were under nutritional stress they were probably travelling to areas they had experienced before.

Most of the caribou on Bathurst Island usually wintered south of Polar Bear Pass and summer to the north (Freeman 1975, Miller et al. 1977b). In late June-early July 1961 all but 13 (estimated) of the 3,565 (estimated) caribou on the Bathurst complex were south of Polar Bear Pass. Bissett (1968) noted that caribou on Bathurst moved northward in the spring from the Dyke Acland Bay and Allison Inlet areas.

Southern Bathurst Island was the most important location for spring and autumn hunts by Inuit from Resolute Bay, Cornwallis Island,

although a few caribou were taken there in June and July (Bissett 1968). Hunters regularly secured caribou on Baker and Moore islands off the southeast coast of Bathurst in late winter and spring (Bissett 1968). In March-April 1973 and 1974, 60% and 74% of the caribou on Bathurst Island (proper) were south of Polar Bear Pass, but in August 1974, only 0-15% were in that zone (Miller and Russell 1975). In August 1974 and June 1975 only 20% and 2% of the observed caribou were south of Polar Bear Pass (Fischer and Duncan 1976). In April 1975, all 10 caribou observed on the island were immediately south of Goodsir Inlet (Fischer and Duncan 1976). All those data indicate that the majority of caribou on Bathurst Island winter south of Polar Bear Pass, they migrate to the north at or before calving in June and they return south during August-October.

Caribou on Prince of Wales and Somerset islands interchange between those islands as well as the Boothia Peninsula. Inuit in the region were aware of those movements (Banfield 1961, Manning and Macpherson 1961, Ernie Lyall pers. comm.). Caribou and their trails were observed by personnel of the Geological Survey of Canada in May 1975 (Fischer and Duncan 1976). The latter authors, based on survey data for the three regions, suggested there was a net movement of 1,400 caribou from Prince of Wales Island to Somerset Island and the Boothia Peninsula during the winter of 1974-75. Aerial studies of inter-island movements in June of 1977 confirmed an extensive movement from Somerset Island to Prince of Wales Island via islands in Peel Sound, and to Russell Island (Miller and Gunn 1978a). A few trails indicated movements north of Russell Island, possibly to Young and Lowther islands in Barrow

Strait and possibly to Bathurst Island. Some crossings of Peel Sound may have occurred after calves were born. Further studies between 16 May and 1 July 1978 revealed a similar movement pattern except that tracks of only three caribou were seen on the sea ice of Barrow Strait north of Russell Island (Miller and Gunn 1979a). Until spring 1979, known springtime inter-island movements of Peary caribou across Peel Sound and Franklin Strait were essentially east to west movements of animals that had spent at least part of their winters on Somerset Island or Boothia Peninsula and then moved to Prince of Wales Island for the summer. But in June of 1979, caribou were seen on the sea-ice of northern Franklin Strait and Peel Sound travelling to the Boothia Peninsula and Somerset Island from Prince of Wales Island (Miller and Kiliaan 1980).

3.3 Reproduction

A study of the relationship between pregnancy incidences and levels of fat reserves of Peary caribou revealed a strong correlation (Parker et al. 1975; Thomas et al. 1976, 1977; Thomas and Broughton 1978). Pregnancy incidences increased from 6-7% pregnant at weights of 51-53 kg to 100% at mean weights of 67 kg or heavier. The low pregnancy incidences were associated with percentages of femoral fat below 50% and with kidney fat indices below 24. Pregnancy incidences increased progressively to 88-100% as the percentages marrow fat and kidney fat indices increased to 79-88% and to 41-95, respectively.

Only relatively heavy yearling females (mean weight 54 kg) with good fat reserves attained puberty. Those yearlings without fat reserves were significantly (P 0.01) lighter at 46 kg (Thomas in prep.), a relationship mirrored by adult females.

3.4 Diets

Data on the winter diets of Peary caribou were obtained by visual estimation of the proportionate composition of plants in rumen samples of 188 animals collected on several islands from 1974 to 1977 (Parker et al. 1975; Thomas et al. 1976, 1977; Thomas and Broughton 1978). Variation in the apparent diets were high among islands and among sites within islands but among-year differences were smaller. Diversity characterized the diets of caribou on Somerset Island, a reflection of diverse habitat types on which access to forage was greater than elsewhere. Mosses, Luzula spp., Dryas integrifolia, Carex spp., Salix arctica, Saxifraga oppositifolia and unidentified grasses and sedges comprised 91% of the rumen contents in the grouped data from all 4 years.

Relatively high proportions of Saxifraga oppositifolia (32%), and the lichens Thamnolia vermiculata (8%), and Cetraria spp. (7%) typified the diets of caribou collected on Prince of Wales Island. Other major components included mosses, Luzula spp. and Salix arctica.

High proportions of mosses (33-59%) occurred in the rumens of Peary caribou collected on Bathurst, Melville, Eglinton and Prince Patrick islands in grouped samples over the 3 - 4 year period. Moss comprised over half of the rumen contents of caribou on Bathurst and

Melville islands in March 1974, when starvation was widespread (Parker et al. 1975; Miller et al. 1977a). Rushes, grasses and sedges were major components in the winter diets of caribou north of Parry Channel.

Parker (1978) used a microhistological technique to assess proportions of forage species in the rumens and concluded that Salix arctica was critical to Peary caribou in winter. The caribou were collected in March-April 1975 on five islands including Bathurst, Prince of Wales and Somerset islands. He found a strong positive correlation between Salix content in the rumens and percentage fat in the femoral marrow. He found a negative correlation between proportions of moss in the rumens and fat in the marrows.

Histological analysis of caribou fecal material indicated that Peary caribou at three locations on Prince of Wales Island utilized predominantly mosses, lichens, herbs and Salix. At Union River on Somerset Island the order in frequency of occurrence was mosses, lichens, evergreen shrubs, sedges and Salix arctica. The data from the same technique indicated that Salix was the major item in the summer diet, with moss, herbs and lichens contributing lesser proportions.

Rumen samples from five caribou shot on Prince of Wales Island on 7 August 1978 averaged 97% Salix arctica. Parker (1978) found that Salix arctica comprised 89, 64 and 82% of fragments in fecal samples of Peary caribou collected in July at sites on Melville, Bathurst and Axel Heiberg islands, respectively. Average values for relative densities of discernable plant fragments in summer-type pellets collected at four sites on Prince of Wales Island were Salix arctica 65%, mosses 16%, herbs 12%, lichens 6% and grasses/sedges 1% (Fischer and Duncan 1976).

The dietary information for Peary caribou suggests that Salix arctica is of critical importance in summer, along with herbs. Peary caribou are catholic, opportunistic feeders in winter, capable of exploiting poorly vegetated sites where a sparse cover of vegetation is accessible because of shallow snow.

3.5 Habitats

Peary caribou in winter select foraging sites with little or no snow cover and sites where the snow is relatively soft. Ranges in snow depths recorded at 16 sites over three winters indicated that minimum depths exceeded 6 cm in two instances and maximum depths surpassed 20 cm in three cases (Parker et al. 1975; Thomas et al. 1976, 1977; Thomas and Broughton 1978).

Thin, hard snow is not a serious barrier to caribou provided that it is underlain with crystalline snow. Of great detriment to caribou is the presence of ice or a hard layer of snow at ground and vegetation level. Such conditions, along with abnormally deep snow, contributed to the starvation of caribou on Bathurst and Melville islands in the winter of 1973-74.

The role of mosses in the energetics of caribou on the Arctic Islands remains uncertain but studies indicated relatively low apparent digestibilities. Rumen fluids from caribou obtained on Prince of Wales Island in March digested only 4-16% of the dry matter of mosses compared with 54-84% for lichens (Thomas and Kroeger 1980).

Russell et al. (1978) found that caribou on Somerset and Prince of Wales islands tended to feed on mesic habitats with medium to sparse

cover and dominated by one or more of Saxifraga oppositifola, Dryas integrifolia, Cassiope tetragona, Carex rupestris or lichens. On Prince of Wales Island the range types used most extensively by caribou were dominated by Saxifraga oppositifolia, Salix arctica, mosses and lichens. Their study confirmed that the Stanwell-Fletcher lowlands and the west coast of Somerset Island from the latitude of Stanwell-Fletcher Lake to Aston Bay were major wintering areas for Peary caribou. Intensive summer use of Prince of Wales Island and little indication of winter use, added credence to the viewpoint that movements between winter ranges on Somerset Island and summer ranges on Prince of Wales Island were traditional.

4. PRESENT KNOWLEDGE OF MUSKOXEN

4.1 Numbers of muskoxen

The north Devon Island population was estimated to vary between 20 and 100 muskoxen from 1908 to 1960 (Harington 1964). Tener (1963) saw only 23 muskoxen on Devon Island in 1961 and estimated that no more than 200 occurred there. Freeman (1971) estimated that 230 muskoxen occurred on northeastern Devon Island. By 1974 the same region supported about 275 muskoxen (Hubert 1974), suggesting that the population was expanding. The winter of 1973-74 caused mortality of muskox calves in the Jones Sound region but the die-off was not as severe as on the Parry Islands.

Estimated numbers of muskoxen on Cornwallis Island were 56 in 1961 (Tener 1963), about 50 (46-104) in 1974 and 10 in April 1975 (Fischer and Duncan 1976). Carcasses of three muskoxen were seen during reconnaissance surveys of the island in March-April 1974 and there was considerable mortality as a result of the severe winter of 1973-74.

Numbers of muskoxen on Bathurst Island decreased from 1,136 in 1961 (Tener 1963), to 672 in 1973, 468 in March 1974 and 164 in August 1974 (Miller et al. 1977a). The decline was attributed to severe winter foraging conditions particularily in 1967-68 and in 1973-74 (Gray 1973, Parker et al. 1975, Miller et al. 1977a).

Four surveys of Prince of Wales Island in 1974 and 1975 yielded estimates of 313-907 muskoxen and 600 was given as the approximate population. Preliminary analysis of survey data in 1980 indicate higher totals (Gunn pers. comm.) .

Only about 15-20 muskoxen occurred on Somerset Island in 1977 but the habitat there could support several hundred (Russell et al. 1978). Twenty-nine muskoxen were seen on Somerset Island during an aerial survey in July 1980 (A. Gunn pers. comm.).

4.2 Distribution and Movements

Muskoxen are numerous on the lowlands of northeastern Devon Island but they are rare elsewhere. Harington (1964) suggested that muskoxen came to the lowlands only a few hundred years ago as no remains were found by archaeologists. Distinct seasonal movements among the lowlands were documented by Hubert (1974). For example, muskoxen were absent from the Truelove lowlands for several months annually.

Muskoxen on Cornwallis Island are confined to the western portion of the island and to the Eleanor Lake region. The best habitat is in and to the south of the wet lowlands in the northwest corner of the island. Muskoxen occasionally occur on Little Cornwallis Island, but seasonal movement patterns are unknown.

On Bathurst Island the highest densities are usually recorded in the southern section of the island. The distribution is generally distinctly coastal except for the Polar Bear Pass region and the lowlands in the southwest (Tener 1963, Gray 1974, Slaney 1975a, Fischer and Duncan 1976, Miller et al. 1977a). In August 1974 almost all the muskoxen were in and south of the Polar Bear Pass region (Fischer and Duncan 1976).

Muskoxen occasionally are found on the islands in Barrow Strait. Some limited movements between Bathurst and Prince of Wales islands is probable.

Muskoxen on Prince of Wales Island are most numerous along east coastal areas from north of Back Bay to Browne Bay (including the Scarp Brook valley), then east to Young Bay and south and west to Guillenard Bay; and along the southwest coast to the Acland Bay region. Fewer muskoxen occur on the northwest and western coastal regions and in the south-central region south of Crooked Lake.

Somerset Island once supported many muskoxen in the Stanwell-Fletcher Lake region as revealed by skulls. Whalers and native people may have exterminated the muskoxen on the island but it was recolonized by muskoxen apparently from Prince of Wales and Prescott islands. In 1975, one herd of 12 animals was reported in the Stanwell-Fletcher Lake region and it has increased somewhat. In 1980, two herds and a single bull were seen on the island (A. Gunn pers. comm.).

4.3 Reproduction

Only general information outlined in the previous sections is known about reproduction in muskoxen. Age of puberty and the interval

between calves is undoubtedly related to the nutritional state. The reduced sexual behaviour in muskoxen on Bathurst Island noted for 3 years after the severe winter of 1967-68 (Gray 1973) indicates that poorly nourished adults do not come into reproductive condition.

The percentage of calves in herds in summer on a regional basis is usually 10-15% (Tener 1965, Hubert 1974, Fischer and Duncan 1976, Miller et al. 1977a). Calves may constitute 20% of the herds in expanding populations (Tener 1963) and proportions as high as 28% have been documented (Fischer and Duncan 1976).

4.4 Diets

The importance of sedges, grasses, and willows in the diets of muskoxen was noted by Tener (1965) from feeding observations and a few rumen samples. Rumen samples from 13 muskoxen collected on Banks Island in August contained 77.0% sedges, 13.3% grasses and 8.4% willow (Wilkinson et al. 1976).

The first quantitative data on the diets of muskoxen from several islands was obtained by Parker (1978) for the Bailey Point (Melville Island), Bracebridge Inlet (Bathurst Island), and Mokka Fiord (Axel Heiberg Island) regions. At all three locations the summer diets were predominantly sedges and grasses (53.1, 80.5, and 48.2%) and willow (43.5, 16.8, and 37.2%), respectively. The most important monocotyledons were Carex stans, Eriophorum triste, and Festuca spp. The winter diets of muskoxen on Devon Island and at Mokka Fiord were also predominantly sedges, willow, and grasses (Parker 1978).

The winter diets of muskoxen at two locations on Prince of Wales Island were 52% mosses, 36% sedges and 11% willow, based on fragments in fecal pellets (Fischer and Duncan 1976). In summer the proportions were 51% willow, 38% sedges and 10% mosses, and in autumn and spring the diets were dominated by sedges (65%) (Fischer and Duncan 1976). Although only a few plant species form the bulk of the diets, a large number of species are utilized especially in summer and some forbs are selected at certain times (Wilkinson et al. 1976, Parker 1978).

4.5 Habitats

The dietary information indicates that muskoxen spend much of their time in wet sedge-dominated habitats and in somewhat drier sedge-willow plant communities. A typical pattern of activity is alternate periods of feeding on sedge meadows and resting in adjacent drier sites. On Bathurst Island the muskoxen alternated feeding and resting periods of about 150 minutes (Gray 1973). At Bailey Point and Mokka Fiord the proportions of feeding to resting were 98:75 min and 136:91 min, respectively (Parker 1978). On Banks Island the ratio was 86:102, perhaps reflecting better foraging conditions there (Wilkinson et al. 1976).

Muskoxen are capable of feeding in meadows where the snow is deep and crusted. Once a meadow with favorable snow conditions is found a herd may remain there for several weeks. In spring (June), the muskoxen feed on elevated sites where the growth of sedges and grasses is earlier than in lowland regions where snow persists and ice forms beneath the snow.

5. KNOWLEDGE GAPS AND PROBLEMS RELATED TO CARIBOU AND MUSKOXEN

5.1 We do not have accurate current counts and estimates of Peary caribou, barren-ground caribou or muskoxen on any of the islands under consideration except for Somerset and Prince of Wales islands, which were surveyed in 1980.

5.2 Our knowledge of seasonal distributions and densities is fragmentary and inadequate for making biological judgements in many matters.

5.3 Our knowledge of seasonal use of forages is fragmentary and we do not know much about patterns of feeding behavior.

5.4 Although we can assume that current numbers of Peary caribou do not approach levels that would tax the production of forages, we do not know much about seasonal unavailability of forages brought on by unfavorable snow or ice conditions.

5.5 Although we know that springtime (May-June and into July in some years) ground fast ice formation can seriously restrict forage availability on much of the better vegetated ranges, we do not know how extensive such restrictions are or their impact on Peary caribou, especially parturient and maternal cows and their newborn calves. We know nothing about how this springtime icing affects muskoxen.

5.6 We do not know if Peary caribou or muskoxen have general or specific calving areas. We assume that they exist for Peary caribou from our fragmentary knowledge of springtime movements on Somerset and Prince of Wales islands. It is unlikely that muskoxen have specific calving grounds but they may have general areas in which they calve from year to year.

5.7 We do not have an adequate understanding of seasonal movements (intra-and inter-island), seasonal distributions and densities of caribou or muskoxen on the islands under consideration.

5.8 We do not know if rutting areas exist or where they are located on the various islands.

5.9 We do not know what impact the current levels of harvesting by Inuit are having on the Peary caribou and barren-ground caribou in the region under consideration.

5.10 We have only a limited knowledge of the social structure and group cohesion of caribou and muskoxen in the area under consideration.

5.11 We know virtually nothing about the tolerance or adaptability of Peary caribou, barren-ground caribou or muskoxen to man and his activities in the Arctic.

5.12 Problems related to the Environment

Peary caribou, barren-ground caribou and muskoxen have evolved in the Arctic and although they are highly adapted and adaptable they sporadically or periodically experience detrimental snow or ice conditions that lead to marked die-offs of adults and loss of calves. Such unfavorable weather conditions may even lead to a failure to breed or conceive, an extreme condition in North American ungulates.

There is nothing that we can do about the adverse weather conditions that lead to starvation due to forage unavailability. We should, however, monitor the populations frequently enough (every 3-5 years) to detect significant changes in their numbers. In order to do that properly, that is, in a way that will give accurate estimates of the

existing situation, we must know the overall home ranges of every population or major segment in the area. This is especially true for Peary caribou because of the existence of inter-island populations. Otherwise we must survey groups of islands in order to monitor numbers. Even then, we would have to know if Peary caribou range beyond the region under consideration.

5.13 Problems related to harvesting by Inuit

The Peary caribou was classified as "threatened" in 1979 (Gunn et al. 1980). The management of Peary caribou is the responsibility of the NWT Wildlife Service but there are no restrictions on the harvests of Peary caribou by Inuit hunters. As mortality due to hunting is additional to natural mortality and it could be significant during low points in the fluctuation of Peary caribou numbers, the role of hunting as a depressant and dampening agent must be considered. Current hunting of caribou by Inuit with modern equipment and great mobility will lead to more extensive and intensive harvesting. The Peary caribou of this region cannot sustain much higher rates of harvest, if their numbers are as low as suspected. What we know about the barren-ground caribou on Baffin Island suggests that there may be over-utilization now (Calef 1978).

If Peary caribou are lost from the region, Inuit hunters most likely will utilize muskoxen, a condition that is already developing on Prince of Wales Island with increasing quotas for muskoxen.

5.14 Problems related to Northern development

Knowledge of the effects of harassment on Peary caribou and muskoxen is limited and has to be largely drawn from parallels with other

ungulates and predicted from descriptions of caribou and muskox behaviour. Most of the concern about potential wildlife problems that industrial exploration and development activities have brought to the Arctic has been for caribou, still an integral part of native culture. The literature on harassment of ungulates is scattered among different subjects such as animal husbandry, ethology, range and wildlife management, physiology and psychology.

There are four main categories of industrial development likely to have an impact on caribou populations, and these categories have been the basis for several recent studies. The potential of pipelines, roads, railways and hydroelectric lines as barriers to caribou have been described by Klein (1971), Miller et al. (1972, 1977a), Child (1973), Banfield (1974), Bergerud (1974), Cowan 1974), LeResche (1975), LeResche and Linderman (1975), Villmo (1975), Cameron and Whitten (1977) and Roby (1976). The effects of on-going and completed seismic lines were observed by Riewe (1973), Freeman (1975) and Slaney (1975a and 1975b). The third category of industrial development is the great increase in the use of aircraft associated with industrial exploration and development. Espmark (1972), Thomson (1972), Klein (1973), McCourt and Horstman (1974), McCourt et al. (1974), Surrendi and DeBock (1976), Calef et al. (1976) and Miller and Gunn (1979b) described caribou responses to fixed-wing aircraft and helicopters. Finally, Calef and Lortie (1973), McCourt et al. (1974) and Surrendi and DeBock (1976) described some caribou responses to permanent installations such as construction camps, oil rigs and compressor stations.

Previous behavioural studies have emphasized three critical aspects of caribou behaviour that increase their susceptibility to harassment, namely migrations, synchronized breeding and calving on discrete traditional areas (Miller et al. 1972, Miller 1974, Dauphine and McClure 1974, Bergerud 1974). Espmark (1970), Thomson (1972) and Miller et al. (1972) also emphasized the importance of socialization in maintaining traditional migrations.

These harassment studies demonstrated differences in the responsitivity of caribou to harassment that coincided with the identified critical phases of the life cycle of caribou. Observations of responses to both pipeline simulations and aircraft harassment identified cow-calf pairs as the most responsive sex and age group. The studies of aircraft harassment, critically reviewed by Geist (1975), all showed that altitude of the aircraft was one of the determinants of the responses, but previous activity, sex and age class, group size, season, surrounding terrain and aircraft type were all considered important.

Most studies of harassment have considered barren-ground caribou. Peary caribou are the least-known caribou subspecies (Jakimchuk 1975), but recent data on numbers and movements (Miller et al. 1977a and 1977b, Miller and Gunn 1978b) suggest this subspecies may be particularly vulnerable to harassment.

There has been to date only one specific study on harassment of muskoxen by aircraft (Miller and Gunn 1979b), and only one study on the effects of seismic activity on muskoxen (Beak 1975). There are some

descriptive accounts of responses to isolated harassment by aircraft (Gray 1974), seismic activity (Urquhart 1973, Riewe 1973, Slaney 1975a and 1975b), and human activity (Hone 1934, Tener 1965).

Tener (1965) outlined the biology of the species and noted some of the adaptations of this unique species to the Arctic. Gray (1973) wrote a descriptive account of muskox behaviour and Smith (1976) described rutting behaviour. In a subsequent paper, Gray (1974) described the characteristic defense formation of muskoxen which, although often caused by low-flying aircraft, probably originated as a defense mechanism against wolf attacks. Other studies of muskoxen have examined productivity (Hubert 1974), range relationships (Wilkinson and Shank 1974), numbers and distributions (Tener 1958, 1963, Fischer and Duncan 1976, Miller et al. 1977a) and domestication (Wilkinson 1974).

Geist (1971, 1975) outlined some effects of harassment primarily on ungulates and noted (1971:419) that "Another serious consequence of persistent disturbance is voluntary withdrawal from available habitat". Beak (1975) suggested that seismic activity subtly modified muskox distribution on Banks Island but both Urquhart (1973) and Riewe (1973) could ascribe no major changes in distribution to seismic activities. Gray (pers. comm.) has suggested that aircraft activities will drive muskoxen from an area. It is difficult to currently evaluate such suggestions, however, as almost nothing is known about the factors influencing muskox distribution.

At present, knowledge of possible effects of harassment on muskoxen has to be largely drawn from parallels with other ungulates and

predicted from descriptions of muskox behaviour. Lent (1974) predicted from his observations of muskox calving that calves would be particularl vulnerable to aircraft disturbance.

The initial responses of ungulates to harassing stimuli are basically similar to the response to a predator. Energetic constraints probably require most animals to minimize the risk of predation and yet minimize the energy expenditure to avoid predation when it is not imminent. For example, caribou primarily rely on their speed to avoid predation, but rather than running needlessly as soon as a predator appears, they wait until it is within a threshold (flushing) distance. The behavioural responses to a harassing agent such as a predator can probably be modified by experience. If the caribou or muskoxen are chased or surprised by the sudden appearance of a harassing agent to the extent of panic behaviour, they may associate the experience with that agent and will probably respond at an extreme level on subsequent occasions. We do not know if such extreme responses are self-reinforcing. There should be less stress with time; they may habituate as the animals become experienced with the harassing agent.

We do not know if some of the variation in response levels to similar intensities of harassment are the result of previous experience with harassment or other factors such as the stability of social order, stressful situations such as a predator attack and individual variation in behaviour.

Peary caribou and muskoxen have differences in the dynamics of their social orders, forage preferences, selection of foraging sites and

the presence (muskoxen) or absence (Peary caribou) of defense in their repertoires of escape behaviour. Those differences contribute to the variations in their responses to harassment. We do not know: (1) the energy cost of the responses and what that means to the animal and population over an extended period of time, and (2) whether there were any undetected behavioural or physiological changes that would become significant over a period of time; for example, a change in reproductive performance.

We need to determine when and where Peary caribou and muskoxen calve. Caribou calving is highly synchronized within a population and most calves are born within a few days of each other. This synchrony means that if the location and timing of calving are known, it is not difficult to adapt construction schedules to avoid disturbance to such vulnerable areas. Muskox calving is a more prolonged event and the existence of calving areas is unknown, but it is likely that a suitable schedule could be made if the proper research was done. The presence of humans and their installations, such as work camps and pump stations along pipelines, has several implications for the future well-being of caribou and muskoxen. Such activities could:

a) interrupt or disrupt restocking of islands or portions of islands that have undergone severe losses of caribou or muskoxen due to environmental stresses (usually caused by snow and ice conditions that reduce forage availability).

b) interrupt or disrupt intra- and inter-island migrations of caribou to traditional seasonal ranges, traditional calving, post-calving and rutting areas.

c) interrupt or disrupt daily feeding activities.

d) reduce the genetic plasticity and long-term survivability of the population by restricting free movements and thus gene flow.

Current concepts of the roles of leadership and socialization in disseminating experience within a population strongly suggest that the unfavourable contact of even a few dominant caribou or muskoxen of a population with a man-made obstruction could affect the subsequent movements of many caribou and muskoxen. We have only fragmentary observations of Peary caribou and muskoxen responses to human installations and they are not sufficient to permit us to review proposals from the private sector or evaluate environmental impact statements. The only cursory information to-date that related to responses of caribou to human activity and installations is fragmentary and needs to be considerably expanded if we are to protect and wisely use Canada's caribou resources.

Muskoxen respond to a predator by assuming a group defense formation, but this behaviour considerably increases their vulnerability to human disturbance. In the past, their defense behaviour led to near extinction over most of their range (Hone 1934) because of the ease with which hunters could kill animals in a group defense formation. The grouping and remaining in place tends to attract the attention and curiosity of humans partly because the muskox is an unique and intrinsically interesting mammal, but also because of the mistaken impression that if the muskoxen are not running away, they are not stressed.

The successful reproduction and rearing of young is sporadic at best for Peary caribou and muskoxen on the Arctic Islands (Tener 1965, Gray 1973, Miller et al. 1977a). In addition, the physical condition of many Peary caribou and muskoxen over 1-year of age is poor and mortality can be high during some years, especially during periods of unfavourable snow and ice conditions (Parker et al. 1975, Thomas et al. 1976, 1977, Miller et al. 1977a). Observations from Prince of Wales Island (Miller and Gunn 1979b) and observations from the western Queen Elizabeth Islands (Miller et al. 1977a) suggest that even in years when reproduction is high, survival of Peary caribou and muskoxen during the first year of life is sometimes low. It is unlikely that annual increments to the population of 10-20% are maintained over the long-term: this is indeed true for the last decade. Therefore, we suggest that harassment has the potential for causing additional stress leading to increased mortality under certain conditions. Any additional mortality could hinder or prevent Peary caribou and muskoxen from maintaining their numbers from year to year. The probability of such mortality requires that some constraints be employed to guard against mortality from harassment. The possibility of additional mortality is particularly important with the current low numbers of Peary caribou on traditional hunting areas and the increased harvest of muskoxen by Inuit.

We do not know the costs of responses to harassment in terms of an individual's energy budget. We do not know whether animals that do not overtly respond are in fact responding at a physiological level and the associated costs. Past work was limited to June through August, the

period when Arctic operations were most economical and most easily carried out. Therefore, we do not know how Peary caribou and muskoxen would respond to harassment from September to June. The late-winter period (March to May) is when animals lack or have their lowest energy reserves and when the effects of harassment may be the most severe.

We do not know the long-term effects of harassment on individuals. Although the energy costs of responses to harassment may appear low, an additional drain of energy over a relatively long period could seriously deplete the energy reserves essential for successful reproduction or survival. At best, we have only a limited understanding of the role of adversive conditioning or habituation in determining changes in response levels over prolonged exposure to harassing stimuli.

The accumulation of affected individuals will affect the population level over the long-term. Although we know that high reproductive success over the long-term for both species is, at best, sporadic, we do not have a good measure of an additive slight loss of reproductive effort or a slight increase in mortality. But we can judge with confidence that such changes would be detrimental and most likely adversely influence the population. We do not understand the degree of affinity to traditional ranges and migration routes by the animals, nor the levels of harassment that might force the animals to abandon ranges or routes or the total consequences of such abandonments. We can, however, predict that almost any interference with the distribution of the animals by foreign activities that drive them from their preferred ranges or cut off migration routes will have a marked effect on the

segment of the population concerned. It will be of little or no benefit to Peary caribou and muskox populations to enact regulations that will partially protect individuals from harassment, if development activities interfere with their movements and turn them from their preferred ranges.

The potential effects on caribou and muskoxen of harassment induced by man and his activities associated with the exploitation of non-renewable resources range from immediate behavioural responses to population decline. Prolonged alterness or flight could theoretically lead to a sequence of detrimental conditions:

(1) alteration in daily activity patterns;

(2) reduced intake and use of forage;

(3) energy loss;

(4) weight loss;

(5) failure to breed;

(6) high calf mortality; and subsequent

(7) population decline.

Prolonged flight could also lead to:

(1) acute pathological conditions (pulmonary emphysema, shock, prolapsed recta, abortion, hyperthermia and stress);

(2) directly to death;

(3) or increased susceptibility to predation or disease; and subsequent

(4) populaion decline. Changes is behavioural patterns could cause short-term responses that lead to detrimental changes in maternal and aggressive behaviours.

Such changes could lead to:

(1) injury;

(2) cow-calf separations;

(3) increased susceptibility to predation or disease; and

(4) subsequently population decline. Changes in behavioural patterns could also lead to long-term changes in

(1) distributions;

(2) cow-calf behaviour patterns;

(3) activity patterns; and

(4) habituation.

As yet, we know virtually nothing about the processes of habituation under field conditions or the role of learning in such processes. This knowledge is perhaps, critical to fostering the compatability of the well-being of caribou and muskoxen populations with northern development.

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